# Experimental Research on Contests

Roman Sheremeta

3 October 2018

# Experimental Research on Contests

Roman M. Sheremeta [a,b,*]

[a] Weatherhead School of Management, Case Western Reserve University
11119 Bellflower Road, Cleveland, OH 44106, USA
[b] Economic Science Institute, Chapman University
One University Drive, Orange, CA 92866, USA

October 3, 2018

**Abstract**

Costly competitions between economic agents are modeled as contests. Researchers use laboratory experiments to study contests and test comparative static predictions of contest theory. Commonly, researchers find that participants' efforts are significantly higher than predicted by the standard Nash equilibrium. Despite overbidding, most comparative static predictions, such as the incentive effect, the size effect, the discouragement effect and others are supported in the laboratory. In addition, experimental studies examine various contest structures, including dynamic contests (such as multi-stage races, wars of attrition, tug-of-wars), multi-dimensional contests (such as Colonel Blotto games), and contests between groups. This article provides a short review of such studies.

*JEL Classifications*: C7, C9, D4, D7, D9, H4, L2, J4, K4, L2, M5
*Keyword*s: Contest; All-pay auction; Tournament; Dynamic Contest; Multi-battle Contest; Multi-dimensional Contest; Group Contest; Rent-seeking; Experiment; Overbidding; Over-dissipation; Incentive Effect; Size Effect; Discouragement Effect; Strategic Momentum

* Corresponding author: Roman Sheremeta, rms246@case.edu and rshereme@gmail.com
I want to thank Tim Cason, Subhasish Chowdhury, Philip Brookins, Cary Deck, Erik Kimbrough, Michael Kirchler, and Kevin Laughren for very helpful comments and suggestions. I remain solely responsible for any errors or omissions.

## 1. Introduction

Costly competitions between economic agents are often modeled as contests. Examples range from litigation and lobbying, to wars and violent global conflicts (Tullock, 1964; Krueger, 1974). The variety of economic, management and political situations that can be described as contests has attracted enormous attention from economic theorists (Konrad, 2009; Vojnovic, 2016). The three canonical models of contests include the Tullock (1980) model of rent-seeking, the Lazear and Rosen (1981) rank-order tournament, and the all-pay auction (Hirshleifer and Riley, 1978; Nalebuff and Stiglitz, 1983). Although the underlying assumptions of these models vary, all models assume that (i) contestants expend costly efforts while competing for a prize and (ii) an individual contestant's probability of winning the prize depends on the contestants' relative efforts and abilities.

Although there is sizable empirical literature examining behavior in contests (Prendergast, 1999; Szymanski, 2003; Connelly et al., 2014), such studies address only a limited set of questions. This is understandable, given the nature of field data. First of all, there is a problem of measurement error, since the researcher can only observe the performance of contestants, which is a function of effort, ability and luck (Ericsson and Charness, 1994). In addition, there is a problem of self-selection and endogeneity (Kimbrough et al., 2018). To circumvent these issues, researchers often use controlled laboratory experiments to study behavior in contests (see the review by Dechenaux et al., 2015).

Controlled experiments allow researchers to test theoretical predictions about contests while minimizing measurement error, and the implications of self-selection and unobservable characteristics. Moreover, most experiments allow direct measurement of individual effort, while controlling for the relative abilities of individuals, as well as relevant parameters of interest (such as the number of players, the number of prizes, and the length of the contest). This article provides a short review of this research.

## 2. Canonical Models of Contests

Using the structure of Dechenaux et al. (2015), assume there are $n$ risk-neutral players competing for a prize value $v$. Each player $i$ expends an effort $e_i$ and bears a cost of effort $c(e_i)$. The performance of player $i$, $y_i$, depends on player $i$'s effort $e_i$ and a random variable $\varepsilon_i$, independently drawn from some common distribution with cumulative distribution function $F$:

$$y_i(e_i, \varepsilon_i) = e_i + a\varepsilon_i. \tag{1}$$

The probability that player $i$ wins the prize depends on player $i$'s performance $y_i$ and the performance of all other $n-1$ players, and it is defined by the following contest success function:

$$p_i(y_i, y_{-i}) = \frac{y_i^r}{\sum_{j=1}^n y_j^r} \text{ if } \sum_{j=1}^n y_j > 0 \text{ and } p_i(y_i, y_{-i}) = \frac{1}{n} \text{ otherwise.} \tag{2}$$

Here, $r \geq 0$ is a sensitivity parameter. The expected payoff for player $i$ is equal to the probability of winning the prize $p_i(y_i, y_{-i})$ times the prize value $v$ minus the cost of effort $c(e_i)$:

$$E(\pi_i) = p_i(y_i, y_{-i})v - c_i(e_i). \tag{3}$$

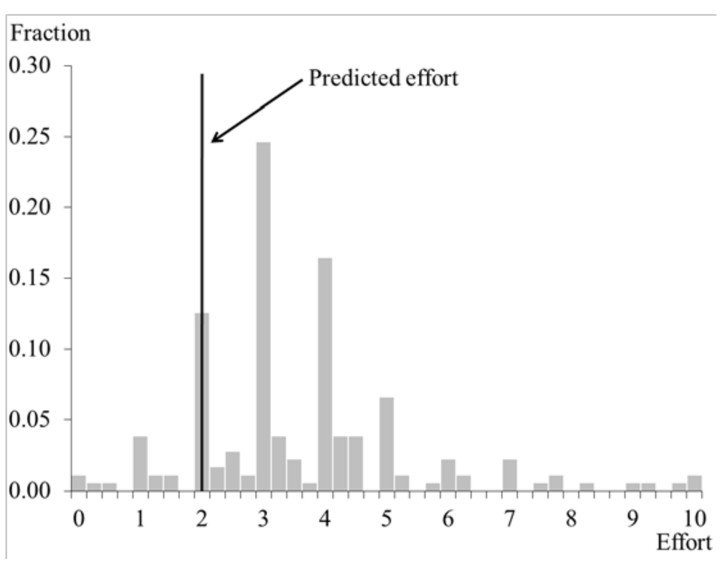
A simple version of a Tullock contest can be obtained by setting $a = 0$ in (1), $r \in (0, \infty)$ in (2), and $c_i(e_i) = e_i$ in (3). To obtain an all-pay auction, we set $a = 0$ in (1), $r = \infty$ in (2), and $c(e_i) = e_i$ in (3). Finally, to obtain a rank-order tournament of Lazear and Rosen (1981), we set $a = 1$ in (1), $r = \infty$ in (2), and $c_i(e_i) = c(e_i)$ in (3), where $c_e > 0$ and $c_{ee} > 0$. The exact Nash equilibria predictions can be found in Konrad (2009) and Vojnovic (2016).

## 3. General Experimental Findings on Contests

### 3.1. Overbidding

One of the most common findings in experimental literature on contests, first discovered by Millner and Pratt (1989), is overbidding – participants in laboratory experiments expend efforts which are substantially higher than predicted by the standard Nash equilibrium. This phenomenon, also known as over-dissipation or over-expenditure, is especially well-documented in lottery contests, i.e., contests in which the sensitivity parameter in (2) is restricted to $r = 1$. Sheremeta (2013) examines a sample of 30 lottery contest experiments and finds that the average effort is 72% higher than predicted by theory. In some cases, the extent of overbidding is so high that participants, on average, receive negative payoffs (Sheremeta and Zhang, 2010; Price and Sheremeta, 2011, 2015; Mago et al., 2016). Figure 1 displays a distribution of efforts commonly observed in contest experiments. The data are taken from Sheremeta (2017). Almost 80% of participants expend higher than predicted effort.

**Figure 1: Distribution of effort in a contest experiment.**




Source: Sheremeta (2017).

Different theories have been offered to explain overbidding in contests (Sheremeta, 2013, 2015). The first explanation is that, in addition to monetary incentives, participants derive a non-monetary utility from winning (Sheremeta, 2010; Price and Sheremeta, 2011, 2015; Cason et al., 2012, 2017). To demonstrate this, Sheremeta (2010) designed a simple method of eliciting the utility of winning – individuals participate in a contest with a monetary prize and then in a contest with no prize. The results of the experiment show that individuals who expend effort just to be recognized as winners also expend higher effort in a contest with a monetary prize.

The second explanation is that participants are prone to mistakes. These mistakes add noise to the Nash equilibrium solution, exacerbating overbidding in contests (Sheremeta, 2011; Chowdhury et al., 2014; Lim et al., 2014). Another explanation is that, rather than maximizing their absolute payoff, participants care about their relative payoffs (Fonseca, 2009; Mago et al., 2016). Finally, recently Sheremeta (2017) showed that impulsivity, measured through a Cognitive Reflection Test, may be one of the most important factors explaining overbidding in contests.

### 3.2. Comparative Static Predictions

Despite significant overbidding, most comparative static predictions of contest theory are supported in the laboratory.

One of the well-established theoretical and empirical results is the "incentive effect": the total effort increases in the size of the prize. One of the first experimental studies to establish the incentive effect in contests is by Bull et al. (1987). The authors show that the total effort in the rank-order tournament increases as prize increases. Similar results are obtained by Morgan et al. (2012) and Sheremeta (2011) in the context of lottery contests.

An important comparative static prediction is the "size effect": the total effort is increasing (non-decreasing) in the number of contestants. Some of the studies that have shown this are by Gneezy and Smorodinsky (2006), Sheremeta (2011), Morgan et al. (2012), and Lim et al. (2014). It is important to emphasize that, although the total effort is increasing in the number of contestants, per capita effort may actually decrease.

When the contest is between asymmetric players, a well-known theoretical result is the "discouragement effect": weaker players strategically cut back effort when facing a stronger player, and as a result, total effort decreases in the degree of asymmetry between players. The discouragement effect has been well supported by experimental research of lottery contests (Fonseca, 2009; Anderson and Freeborn, 2010; Kimbrough et al., 2014), all-pay auctions (Davis and Reilly, 1998; Llorente-Saguer et al., 2016), rank-order tournaments (Weigelt et al., 1989; Schotter and Weigelt, 1992), and other contests (Cason et al., 2010; Gill and Prowse, 2012).

Another well-known comparative static result is that effort decreases in the variance of noise, i.e., the variance of a random variable $\varepsilon_i$ in equation (1). The intuition is that when the probability of winning depends more on noise than on effort, then there is little incentive to expend effort. This intuition has been shown to hold true in rank-order tournaments (Bull et al., 1987; Cason et al., 2018) and Tullock-type contests (Potters et al., 1998; Davis and Reilly, 1998; Mago et al., 2013).

## 4. Other Contests

### 4.1. Dynamic Contests

Many contests have a dynamic structure, with one player making a move after observing the move of the other player. In such sequential contests, the first-mover often has an advantage over the follower. Although some experimental studies find evidence for the first-mover advantage (Shogren and Baik, 1992; Fonseca, 2009; Gill and Prowse, 2012), others do not (Weimann et al., 2000; Vogt et al., 2002). This is because, instead of best responding and maximizing their expected payoff, second-movers often seek to equalize the probability of winning across players (Vogt et al., 2002).

Perhaps the most popular dynamic contest is the multi-stage race (also known as the best-of-*n* contest). In such a contest, a player needs to win a certain number of battles (contests) in order to win the entire contest. One of the first experimental studies of races was done by Zizzo (2002), who found a positive correlation between effort in a given battle and progress in the race. Follow-up studies by Ryvkin (2011), Deck and Sheremeta (2012), and Mago et al. (2013) have examined the questions of fatigue, preemption and "strategic momentum" in the context of races.

Other types of dynamic contests, called the "war of attrition" and the "tug-of-war", also have been studied in the laboratory. The war of attrition – a dynamic contest in which players try to outlast each other – has been studied by Hörisch and Kirchkamp's (2010), DeScioli and Wilson (2011), and Oprea et al. (2013). The tug-of-war – a dynamic contest in which a player wins the war if the difference in the number of battle victories exceeds some threshold – has been studied by Deck and Sheremeta (2017).

Generally, these studies find support for the comparative static predictions of the theory. For example, experimental studies of dynamic contests find that effort increases in the prize value and the size of intermediate rewards (Mago et al., 2013; Gelder and Kovenock, 2017), and that it decreases in the magnitude of "strategic momentum," i.e., how far one player is ahead of the other (Mago et al 2013; Mago and Sheremeta, 2018). Also, as predicted, asymmetric contests tend to be resolved in favor of the contestant with the advantage (DeScioli and Wilson, 2011; Oprea et al., 2013).

**4.2. Multi-dimensional Contests**

Many competitions resemble games of multi- dimensional contests. Perhaps one of the most famous is the Colonel Blotto game, in which two players simultaneously compete in several contests and the winning player is the player who wins the most contests. Two of the earlier experimental studies examining behavior in the Colonel Blotto game were done by Avrahami and Kareev (2009) and Chowdhury et al. (2013). Both studies find support for the qualitative predictions of the theory. In particular, the weaker player (with lower budget) uses a "guerilla warfare" strategy that stochastically allocates zero effort to a subset of contests, while the stronger players use a "stochastic complete coverage" strategy, expending positive effort in each contest.

In additional to studying the classical constant-sum Colonel Blotto game, experimental studies have examined non-constant-sum multi-dimensional contests in the context of all-pay auctions (Arad and Rubinstein, 2012; Holt et al., 2016; Montero et al., 2016; Mago and Sheremeta, 2017; Kovenock et al., 2018) and lottery contests (Deck et al., 2017; Kovenock et al., 2018; Mago and Sheremeta, 2018). Although, generally, these studies find support for the comparative static predictions, many studies find one notable deviation from the theory. Specifically, contrary to the theory, participants often choose to focus on the "minimal winning sets" – the sets of contests which are sufficient for victory (Deck et al., 2017).

### 4.3. Group Contests

Group contests are prevalent in the field. One interesting feature of group contests is that they can create two competing incentives: First, in order to succeed, members of the same group have incentives to cooperate with each other by expending effort. However, since effort is costly, each member also has an incentive to abstain from expending any effort and instead free-ride on the efforts of other group members. Contest theory predicts that the intensity of competition between groups and the amount of free-riding within groups depends on the group size, sharing rule, group impact function (i.e., a function specifying how individual efforts impact group performance), contest success function, and heterogeneity of players. There is a growing experimental literature testing these theoretical predictions (see the review by Sheremeta, 2018).

Compared to contests between individuals, there is even more overbidding in group contests (Abbink et al., 2010; Ahn et al., 2011). Such overbidding is usually explained by the fact that (i) participants overbid when competing against other participants (Sheremeta, 2013, 2015) and (ii) participants contribute to the group when cooperating with own group members (Ledyard et al, 1995). Another explanation takes its roots in parochial altruism (Bernhard et al., 2006) and group identity (Cason et al., 2012; Chowdhury et al., 2016), suggesting that individuals simultaneously display altruism toward in-group members along with hostility toward out-group individuals.

Despite overbidding, most studies on group contests find support for the comparative static predictions of the theory. For example, as predicted by the theory, experimental studies find that individual efforts are higher when members of the group are rewarded proportionally to their performance than when they are rewarded equally independent of their performance (Amaldoss et al., 2000; Gunnthorsdottir and Rapoport, 2006; Kugler et al., 2010; Majerczyk et al., 2017). Also, consistent with the theory, behavior of individuals crucially depends on the group impact function, with the perfect-substitutes function generating the highest group effort (Abbink et al., 2010; Ahn et al., 2011; Ke et al., 2013, 2015), the weakest-link function generating the least free-riding (Cason et al., 2012, 2017; Brookins et al., 2018), and the best-shot function generating the highest relative effort by strong players (Sheremeta, 2011). Another prediction supported by the data is that when players are heterogeneous, stronger players expend more effort and weaker players are more likely to free-ride; this is what Mancur Olson referred to as "exploitation of the great by the small", and is observed in experiments by Sheremeta (2011), Brookins et al. (2015, 2018), Hargreaves Heap et al. (2015) and Bhattacharya (2016).

The most notable comparative static prediction of the theory which is not supported by the data is the "group size paradox" (Olson, 1965). Almost all existing experimental studies examining the impact of group size on behavior in group contests find that larger groups are more likely to win than smaller groups, even when theory predicts otherwise (Rapoport and Bornstein, 1989; Abbink et al., 2010; Kugler et al., 2010; Ahn et al., 2011; Ke, 2013). So, while weak players may exploit strong players within their own large group by free-riding, it is not to the detriment of the group's payoff in the broader contest, as Olson would have anticipated.

## 5. Concluding Remarks

Over the past two decades researchers have used laboratory experiments to examine contests and test comparative static predictions of contest theory. Commonly, researchers find that in contest experiments participants expend efforts which are significantly higher than predicted by the standard Nash equilibrium. Despite overbidding, most comparative static predictions, such as the incentive effect, the size effect, the discouragement effect and others are supported in the laboratory. In addition, experimental studies examine various contest structures, including dynamic contests (such as multi-stage races, wars of attrition, tug-of-wars), multi-dimensional contests (such as Colonel Blotto games), and contests between groups.

Given the space constraints, this review did not cover the issues of contest design, incomplete information, endogenous entry, risk, sabotage, alliances, demographic differences, etc. The reader interested in these and other issues examined by experimental research on contests should consult the surveys of Sheremeta (2013, 2015, 2016, and 2018), Chowdhury and Gürtler (2015), Dechenaux et al. (2015), and Kimbrough et al. (2018).

## References

Abbink, K., Brandts, J., Herrmann, B. & Orzen, H. (2010). Inter-group conflict and intra-group punishment in an experimental contest game. American Economic Review, 100, 420-447.

Ahn, T.K., R, Isaac, M. & Salmon, T.C. (2011). Rent seeking in groups. International Journal of Industrial Organization, 29, 116-125.

Amaldoss, W., Meyer, R.J., Raju, J.S. & Rapoport, A. (2000). Collaborating to compete: A game-theoretical model and empirical investigation of the effect of profit-sharing arrangement and type of alliance. Marketing Science, 19, 105-126.

Anderson, L.A. & Freeborn, B.A. (2010). Varying the intensity of competition in a multiple prize rent seeking experiment. Public Choice, 143, 237-254.

Arad, A. & Rubinstein, A. (2012). Multi-dimensional iterative reasoning in action: The case of the colonel blotto game. Journal of Economic Behavior and Organization, 84, 571-585.

Bernhard, H., Fischbacher, U., & Fehr, E. (2006). Parochial altruism in humans. Nature, 442, 912-915.

Bhattacharya, P. (2016). Inter-team contests with power differential. Journal of Economic Behavior & Organization, 132, 157-175.

Brookins, P., Lightle, J. P., & Ryvkin, D. (2015). An experimental study of sorting in group contests. Labour Economics, 35, 16-25.

Brookins, P., Lightle, J. P., & Ryvkin, D. (2018). Sorting and communication in weak-link group contests. Journal of Economic Behavior & Organization, 152, 64-80.

Cason, T. N., Masters, W. A., & Sheremeta, R. M. (2018). Winner-take-all and proportional-prize contests: Theory and experimental results. Journal of Economic Behavior & Organization, forthcoming.

Cason, T.N., Masters, W.A., & Sheremeta, R.M. (2010). Entry into winner-take-all and proportional-prize contests: An experimental study. Journal of Public Economics, 94, 604-611.

Cason, T.N., Sheremeta, R.M., & Zhang, J. (2012). Communication and efficiency in competitive coordination games. Games and Economic Behavior, 76, 26-43.

Cason, T.N., Sheremeta, R.M., & Zhang, J. (2017). Asymmetric and endogenous communication in competition between groups. Experimental Economics, 20, 946-972.

Chowdhury, S.M., & Gürtler, O. (2015). Sabotage in contests: a survey. Public Choice, 164, 135-155.

Chowdhury, S.M., Sheremeta, R.M., & Turocy, T.L. (2014). Overbidding and overspreading in rent-seeking experiments: Cost structure and prize allocation rules. Games and Economic Behavior, 87, 224-238.

Connelly, B.L., Tihanyi, L., Crook, T.R., & Gangloff, K.A. (2014). Tournament theory thirty years of contests and competitions. Journal of Management, 40, 16-47.

Davis, D., & Reilly, R. (1998). Do many cooks always spoil the stew? An experimental analysis of rent seeking and the role of a strategic buyer. Public Choice, 95, 89-115.

Dechenaux, E., Kovenock, D., & Sheremeta, R. M. (2015). A survey of experimental research on contests, all-pay auctions and tournaments. Experimental Economics, 18, 609-669.

Deck, C., & Sheremeta, R.M. (2012). Fight or flight? Defending against sequential attacks in the game of siege. Journal of Conflict Resolution, 56, 1069-1088.

Deck, C., & Sheremeta, R.M. (2017). The tug-of-war in the laboratory. Working Paper.

Deck, C., Sarangi, S., & Wiser, M. (2017). An experimental investigation of simultaneous multi-battle contests with strategic complementarities. Journal of Economic Psychology, 63, 117-134.
DeScioli, P. & Wilson, B.J. (2011). The territorial foundations of human property. Evolution and Human Behavior, 32, 297-304.
Ericsson, K.A. & Charness, N. (1994). Expert performance: Its structure and acquisition. American Psychologist, 49, 725 - 747.
Fonseca, M.A. (2009). An experimental investigation of asymmetric contests. International Journal of Industrial Organization, 27, 582-591.
Gelder, A., & Kovenock, D. (2017). Dynamic behavior and player types in majoritarian multi-battle contests. Games and Economic Behavior, 104, 444-455.
Gill, D., & Prowse, V. (2012). A structural analysis of disappointment aversion in a real effort competition. American Economic Review, 102, 469-503.
Gneezy, U. & Smorodinsky, R. (2006). All-pay auctions – An experimental study. Journal of Economic Behavior and Organization, 61, 255-275.
Gunnthorsdottir, A., & Rapoport, A. (2006). Embedding social dilemmas in intergroup competition reduces free-riding. Organizational Behavior and Human Decision Processes, 101, 184-199.
Hargreaves Heap, S., Ramalingam, A., Ramalingam, S., & Stoddard, B. (2015). 'Doggedness' or 'disengagement'? An experiment on the effect of inequality in endowment on behavior in team competitions. Journal of Economic Behavior & Organization, 120, 80-93.
Hirshleifer, J. & Riley, J.G. (1978). Elements of the theory of auctions and contests. UCLA, Working Papers.
Holt, C., Kydd, A., Razzolini, L., & Sheremeta, R.M. (2016). The paradox of misaligned profiling: Theory and experimental evidence. Journal of Conflict Resolution, 60, 482-500.
Hörisch, H. & Kirchkamp, O. (2010). Less fighting than expected - Experiments with wars of attrition and all-pay auctions. Public Choice, 144, 347-367.
Ke, C. (2013). Fight alone or together? The need to belong. Working Paper.
Ke, C., Konrad, K.A. & Morath, F. (2013). Brothers in arms – An experiment on the alliance puzzle. Games and Economic Behavior, 77, 61-76.
Ke, C., Konrad, K.A., & Morath, F. (2015). Alliances in the shadow of conflict. Economic Inquiry, 53, 854-871.
Kimbrough, E.O., Laughren, K., & Sheremeta, R. (2018). War and conflict in economics: Theories, applications, and recent trends. Journal of Economic Behavior & Organization, forthcoming.
Kimbrough, E.O., Sheremeta, R.M. & Shields, T.W. (2014). When parity promotes peace: Resolving conflict between asymmetric agents. Journal of Economic Behavior and Organization, 99, 96-108.
Konrad, K.A. (2009). Strategy and dynamics in contests. New York, NY: Oxford University Press.
Kovenock, D., Roberson, B. & Sheremeta, R.M. (2018). The attack and defense of weakest-link networks. Public Choice, forthcoming.
Krueger, A.O. (1974). The political economy of the rent-seeking society. American Economic Review, 64, 291-303.

Kugler, T., Rapoport A. & Pazy, A. (2010). Public good provision in inter-group conflicts: Effects of asymmetry and profit-sharing rule. Journal of Behavioral Decision Making, 23, 421-438.

Lazear, E.P. & Rosen, S. (1981). Rank-order tournaments as optimum labor contracts. Journal of Political Economy, 89, 841-864.

Ledyard, J. (1995). Public goods: A survey of experimental research. In J. Kagel and A.E. Roth (Eds.) Handbook of Experimental Economics, Princeton, NJ.

Lim, W., Matros, A., & Turocy, T. L. (2014). Bounded rationality and group size in Tullock contests: Experimental evidence. Journal of Economic Behavior and Organization, 99, 155-167.

Llorente-Saguer, A., Sheremeta, R.M., & Szech, N. (2016). How to design contests between heterogeneous contestants: An experimental study of tie-breaks and bid-caps in all-pay auctions. Working Paper.

Mago, S.D. & Sheremeta, R.M. (2017). Multi-battle contests: An experimental study. Southern Economic Journal, 84, 407-425.

Mago, S.D., & Sheremeta, R.M. (2018). The New Hampshire effect: Behavior in sequential and simultaneous election contests. Experimental Economics, forthcoming.

Mago, S.D., Savikhin, A.C., & Sheremeta, R.M. (2016). Facing your opponents: Social identification and information feedback in contests. Journal of Conflict Resolution, 60, 459-481.

Mago, S.D., Sheremeta, R.M. & Yates, A. (2013). Best-of-three contest experiments: Strategic versus psychological momentum. International Journal of Industrial Organization, 31, 287-296.

Majerczyk, M., Sheremeta, R.M., & Tian, Y. (2017). Adding tournament to tournament: Combining between-team and within-team incentives. Working Paper.

Millner, E.L. & Pratt, M.D. (1989). An Experimental Investigation of Efficient Rent-Seeking. Public Choice, 62, 139-151.

Montero, M., Possajennikov, A., Sefton, M., & Turocy, T.L. (2016). Majoritarian Blotto contests with asymmetric battlefields: An experiment on Apex games. Economic Theory, 61, 55-89.

Morgan, J., Orzen, H. & Sefton, M. (2012). Endogenous entry in contests. Economic Theory, 51, 435-463.

Nalebuff, B.J. & Stiglitz, J.E. (1983). Prizes and incentives: Towards a general theory of compensation and competition. Bell Journal of Economics, 14, 21-43.

Olson, M.J., (1965). The logic of collective action. Cambridge, MA.: Harvard University Press.

Oprea, R., Wilson, B.J. & Zillante, A. (2013). War of attrition: Evidence from a laboratory experiment on market exit. Economic Inquiry, 51, 2018–2027.

Potters, J.C., De Vries, C.G., & Van Winden, F. (1998). An experimental examination of rational rent seeking. European Journal of Political Economy, 14, 783-800.

Prendergast, C. (1999). The provision of incentives in firms. Journal of Economic Literature, 37, 7-63.

Price, C.R., & Sheremeta, R.M. (2011). Endowment effects in contests. Economics Letters, 111, 217-219.

Price, C.R., & Sheremeta, R.M. (2015). Endowment origin, demographic effects and individual preferences in contests. Journal of Economics and Management Strategy, 24, 597-619.

Rapoport, A., & Bornstein, G. (1989). Solving public goods problems in competition between equal and unequal size groups. Journal of Conflict Resolution, 33, 460-479.

Ryvkin, D. (2011). Fatigue in dynamic tournaments. Journal of Economics and Management Strategy, 20, 1011-1041.

Schotter, A., & Weigelt, K. (1992). Asymmetric tournaments, equal opportunity laws, and affirmative action: Some experimental results. Quarterly Journal of Economics, 107, 511-539.

Sheremeta, R.M. (2010). Experimental comparison of multi-stage and one-stage contests. Games and Economic Behavior, 68, 731-747.

Sheremeta, R.M. (2011). Contest design: An experimental investigation. Economic Inquiry, 49, 573-590.

Sheremeta, R.M. (2011). Perfect-substitutes, best-shot, and weakest-link contests between groups. Korean Economic Review, 27, 5-32.

Sheremeta, R.M. (2013). Overbidding and heterogeneous behavior in contest experiments. Journal of Economic Surveys, 27, 491-514.

Sheremeta, R.M. (2015). Behavioral dimensions of contests. In Congleton, R.D., Hillman, A.L., (Eds.), Companion to political economy of rent seeking, London: Edward Elgar, pp. 150-164.

Sheremeta, R.M. (2016). The pros and cons of workplace tournaments. IZA World of Labor, 302, 1-10.

Sheremeta, R.M. (2017). Impulsive behavior in competition: Testing theories of overbidding in rent-seeking contests. Working Paper.

Sheremeta, R.M. (2018). Behavior in group contests: A review of experimental research. Journal of Economic Surveys, forthcoming.

Sheremeta, R.M., & Zhang, J. (2010). Can groups solve the problem of over-bidding in contests? Social Choice and Welfare, 35, 175-197.

Shogren, J.F. & Baik, K.H. (1992). Favorites and underdogs: Strategic behavior in an experimental contest. Public Choice, 74, 191-205.

Szymanski, S. (2003). The economic design of sporting contests. Journal of Economic Literature, 41, 1137-1187.

Tullock, G. (1980). Efficient rent seeking. In James M. Buchanan, Robert D. Tollison, Gordon Tullock, (Eds.), Toward a theory of the rent-seeking society. College Station, TX: Texas A&M University Press, pp. 97-112.

Vogt, C., Weimann, J. & Yang, C.L. (2002). Efficient rent-seeking in experiment. Public Choice, 110, 67-78.

Vojnovic, M. (2016). Contest theory: Incentive mechanisms and ranking methods. Cambridge University Press.

Weigelt, K., Dukerich, J., & Schotter, A. (1989). Reactions to discrimination in an incentive pay compensation scheme: A game-theoretic approach. Organizational Behavior and Human Decision Processes, 44, 26-44.

Weimann, J., Yang, C.L. & Vogt, C. (2000). An experiment on sequential rent seeking. Journal of Economic Behavior and Organization, 41, 405-426.

Zizzo, D.J. (2002). Racing with uncertainty: A patent race experiment. International Journal of Industrial Organization, 20, 877-902.